SOLUTION PHENOMENA IN THE BASAL ONEOTA DOLOMITE.

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The systemic contact between the Cambrian and Ordovician formations in the upper Mississippi valley occurs between the Jordan sandstone and Oneota dolomite, of Cambrian and Ordovician age, respectively. An erosional unconformity at this contact is suggested by a red residual clay zone, present at places along the contact, and to irregularities in the normal bedding of the sandstone and dolomite.

The red clay is not always present below the dolomite, but is developed where evidence of solution of the dolomite is found. The Oneota is strongly jointed from the present surface to its base. Effect of solution along the joints is shown by the smooth, rounded, and somewhat undulatory joint surfaces and also by the concentration of iron oxide and clay so frequently found coating the surface of the dolomite in these channelways.

The joints are now filled with silt and sandy silt which very closely resemble the clastic material occurring immediately below the dolomite. The bedding in the joint filling material bends downward at the walls of the joints in the lower portion of the openings but no structure occurs in these fillings in the higher portions of the joints. The clastic material below the dolomite is deformed in many of the outcrops, the greatest deformation is below the zone of most intense jointing. At these places the undeformed stratification of the sandstone can be followed beneath a large joint where striking re-entrant angles have been formed by solution widening at the bottom of the joints. These re-entrants frequently penetrate the dolomite several feet. The otherwise horizontal bedding planes arch into such joints in miniature anticlines which show squeezing on the flanks with thickening at the axes. Material from the axes is clearly squeezed upward into the joints for considerable distances. Figure 2 illustrates the deformation of the clastic material at the base of a joint where solution has enlarged it. The Oneota is invariably broken and disturbed by settling where these clay and sandstone re-entrants and joint fillings occur, the intensity and size of the fractures in

the dolomite is proportional to the squeezing displayed in the sandstone.

Winchell and Upham* noted these irregularities at the base of the dolomite at numerous points along Minnesota river and its tributaries. They suggested downward migration of Cretaceous clays and silts along joints in the Oneota during Cretaceous time and assumed the clays were then carried into widespread solution cavities at the base of the Oneota where the stratification developed in these clays conformed to the shape of the openings.

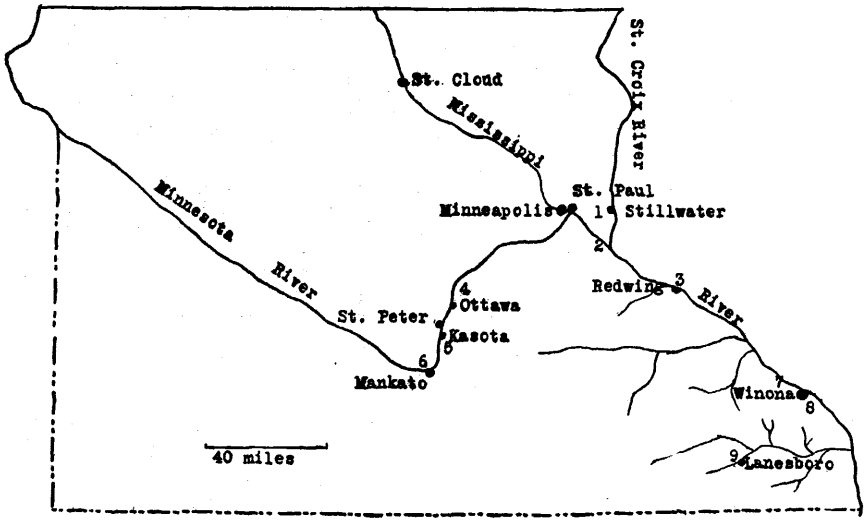

FIG. 1. Southern Minnesota. Numbers indicate location of sections studied in detail.

The numerous joints in the Oneota dolomite furnished excellent channels for downward flowing waters. On reaching the sandstone the waters spread laterally, developing small solution cavities at the base of the dolomite over rather extensive areas. This phenomenon would be especially developed at a time when the level of the groundwater table closely approached the contact plane between the two formations. The top of the Jordan, shown in Figure 2, is a fine-grained water-bearing sandstone. The fineness of the texture even at

*Upham, Warren: Geol. and Nat. Hist. Surv. of Minn., Vol. I, pp. 432–438, 1872–1882.

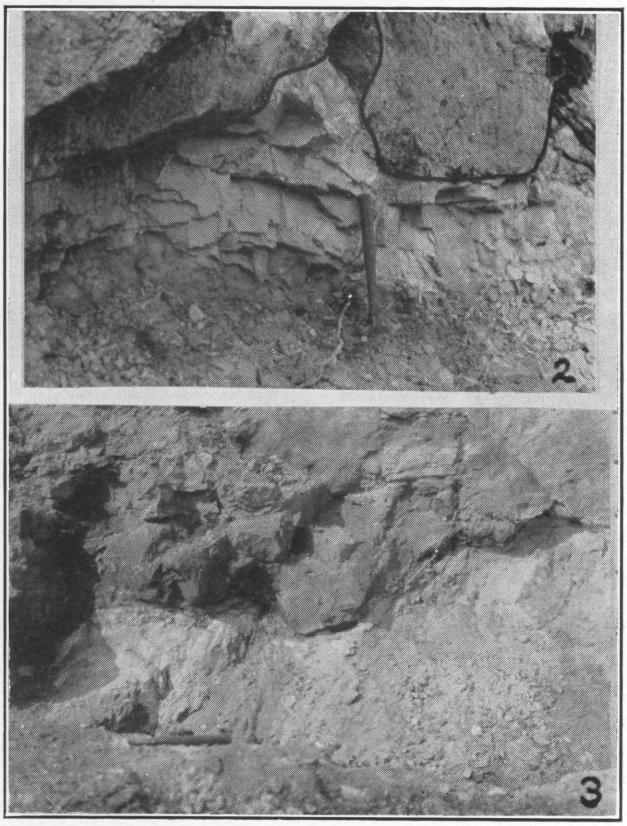

FIG. 2. Deformation of the fine-grained clastic material by solution and settling of the overlying Oneota dolomite. Penetration of the folded bed into a joint plane is well shown. Silbey Park, Mankato, Minn.

FIG. 3. Solution and settling of the Oneota has resulted in deformation of the underlying clastic material. Exposure at St. Peter, Minn.

present causes the water to be held for some time after the coarser underlying layers are dry. Water passing downward along the joints in the Oneota is slowed up in its downward motion on reaching this fine sandstone, resulting in lateral spreading, giving rise to the conditions necessary for the accomplishment of the observed solution effects. In Figure 3 the relationship between a medium-textured phase of the Jordan in contact with the Oneota is shown. The sandstone is massive, thus masking the irregularities in the bedding planes although the irregular re-entrants at the contact are very well developed. Downward moving waters would not be slowed up under such conditions on reaching the sandstone unless the groundwater table roughly coincided with the contact of the sandstone and dolomite. Since extensive solution did occur under this condition the above relationship is assumed to have existed at some time prior to the settling of the dolomite into its present position.

As solution progressed the sandstone below was deformed and squeezed into its present position by settling of the dolomite due to irregular sinking of the unsupported and weakened portions. In some cases the sandstone has been forced 15 to 20 feet upward along the joints in the dolomite, at times it no doubt was forced even greater distances upward, but erosion has removed the higher beds so no greater measurements were secured. It is assumed that settling of the dolomite approximately kept pace with solution, preventing accumulation of irregular dolomite blocks on the floor of the caverns, since no such blocks have been found. The deformation of the very fine-grained friable sandstone or silt zone at the top of the Jordan is expressed by an irregular series of small folds definitely showing thinning on the flanks with thickening along the axes. These folds have their axes under joints in the dolomite which have been filled by the injection of the sandstone during the period of settling of the blocks. On the highway from Mankato to New Ulm, a short distance out of Mankato, maximum deformation of the Jordan was observed. Here the Jordan has been squeezed into folds 10 to 15 feet high. At this locality the Oneota shows the effect of fracture and settling very clearly by the great disturbance in the normal bedding.

At several localities, Stillwater, Ottawa, St. Peter, Mankato, and numerous places noted by Winchell and Upham, concentrations of iron oxide and clay ranging in thickness from a

fraction of an inch to several inches occur beneath the dolomite and along the walls of the numerous joints. This concentration of iron oxide and clay suggests circulation of ground water which dissolved the dolomite along these joints and at the contact of the dolomite and underlying clastics. It is not thought that these concentrated materials indicate a residual accumulation on an ancient land surface since they not only occur at the base of the dolomite but also along the edge of joints widened by solution.

Solution of this sort would result in a concentration of the residual minerals of the Oneota on the top layer of the Jordan sandstone. At one locality, Ottawa on Minnesota river, such a concentration occurs.

The time during which the Oneota settled into the upper Jordan can not be definitely stated, but was no doubt when the competency of the dolomite was low. Settling occurred either when sufficient reduction in thickness of the poorly supported formation was accomplished, or when the added weight of one of the Pleistocene ice sheets increased the load beyond the strength of the weakened formation. It is thought that the settling took place in Tertiary or post-Tertiary time, but no evidence can be presented in support of such a view other than a theoretical consideration of the thinning necessary for failure of the formation.

Heredity in Man.

A British biologist presents in this volume a most interesting and valuable account of the applications of genetic principles to man's welfare. The determination of the type of inheritance involved in human characters is not at all the relatively simple problem which it proves to be in many plants and animals. Methods for such determinations in man are presented and discussed. The possibilities and limitations involved in the mapping of human chromosomes are touched upon. Twins and their bearing on problems of human heredity are taken up with a precise analysis of existing material. Races, populations, and social groups are all subjected to the same genetic analysis, with the result that some of the older orthodox "rule-of-thumb" genetic pronouncements are severely shaken.—L. H. S.

Genetic Principles in Medicine and Social Science, by Lancelot Hogben. 230 pp. New York, Alfred A. Knopf Co., 1932.